

AD-A080 613

DEFENCE RESEARCH ESTABLISHMENT OTTAWA (ONTARIO)

F/6 13/6

CORRECTIONS MADE TO 'AREAL' MODULE OF THE AMC 74 MOBILITY MODEL--ETC(U)

UNCLASSIFIED

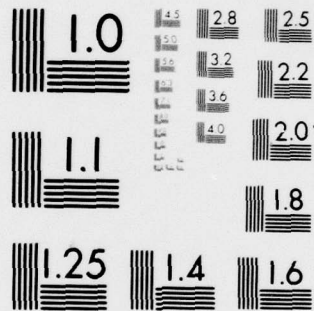
NOV 79 M K NS
DREO-TN-79-29

NL

OF
AD
A080613



END
DATE
FILMED
3 - 80
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ADA080613

3

RESEARCH AND DEVELOPMENT BRANCH

DEPARTMENT OF NATIONAL DEFENCE
CANADA

DDC
RECEIVED
FEB 14 1980
E

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

7 TECHNICAL NOTE NO. 79-29

Aug 77-Jul 78

6

CORRECTIONS MADE TO 'AREAL' MODULE
OF THE AMC 74 MOBILITY MODEL

by

W.K. Ng

Vehicle Mobility Section

10 Winson K./Ng

14 DREG-TN-79-29

PROJECT NO.
24A00

12 18

11 NOVEMBER 1979
OTTAWA

This document has been approved
for public release and sale; its
distribution is unlimited.

404576

LB

UNCLASSIFIED

ABSTRACT

This technical note documents the corrections and changes made to the AMC 74 Mobility Model as of July 1978. The changes reflect the programming and mathematical errors discovered in the program as a result of in-house study and testing of the model. The corrections were made with the concurrence of the U.S. Army TARADCOM, the organization responsible for the development of the model.

RÉSUMÉ

Cette note technique décrit les corrections et changements apportés au "AMC 74 Mobility Model" jusqu'en juillet 78. Les changements résultent d'erreurs de programmation et d'erreurs mathématiques découvertes dans le programme à la suite de tests effectués sur le modèle et d'études de laboratoire. Les corrections furent effectuées avec la collaboration de l'organisme responsable du développement du modèle: "l'US Army TARADCOM".

NON-CLASSIFIÉ

BACKGROUND

In July 1977 the AMC 74 Mobility Model, also known as the U.S. Army Mobility Model, was released by the U.S. Army TARADCOM (Tank Automotive Research and Development Command) to Canada, France, the Federal Republic of Germany, the Netherlands and the United Kingdom. In December 1977 NATO AC225/P11 accepted this model as an initial NATO Reference Mobility Model, subject to further use and application by NATO members.

The AMC 74 Mobility Model has been installed and tested on two computer systems in Canada. During the testing a number of errors was detected in the program. These errors were due to mistakes in programming and mathematical formulation of equations. Corrections were made, in concurrence with TARADCOM, to preserve the design philosophy of the Model and computational capabilities of the program. This document is a compilation of the corrections made at DREO during the period of August 1977 to July 1978.

Accession For	
NTIC GRA&I	<input checked="checked" type="checkbox"/>
DEC TAB	
Unannounced	
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or special
A	

INTRODUCTION

The AMC 74 Mobility Model, developed by the combined effort of several U.S. Army organizations, is a computerized simulation for predicting vehicle performance over various types of terrain. Using the existing technology and methodology relating to vehicle-terrain-driver system, an analytical technique was developed for quantitatively assessing the performance of a vehicle, in terms of speed, in a specified operational environment. As the name implies, AMC 74 is an updated version of AMC 71, a first generation model assembled during the early stages of development.

Under the auspices of a NATO Panel AC225.P11, AMC 74 has been designated as an initial NATO Research Mobility Model, in an attempt to standardize an analytical technique for evaluating vehicle performance. A Working Group, AC225/P11 WG 1, consisting of six countries (Canada, France, the Federal Republic of Germany, the Netherlands, the United Kingdom and the United States), was established to deal with the use and application of the Model, its maintenance and future development.

In July 1977 the AMC 74 Mobility Model, documented in a magnetic tape, was released by the U.S. Army TARADCOM to other WG member countries. The tape contained the main model, two sub-models i.e the Ride Dynamics Module and the Obstacle Crossing Module, several vehicle and terrain data files, along with a scenario file and a job-control file. The two sub-models, run separately, were developed to provide part of the input requirements in the vehicle file for use in the main simulation model, the AREAL Module. A document entitled "The AMC 74 Mobility Model" (1) was distributed earlier at a WG meeting. However, no user's manual was provided.

After the Model was received in Canada, it was first tested on a CDC CYBER 74 computer at the Dept. of Energy, Mines and Resources, and later on the Honeywell Sigma 9 at DREO. At the initial stage of installation of the Model it was discovered that inconsistencies existed between the program documented in the tape and the AMC 74 report. After several test runs it soon became obvious that the Model contained errors and programming 'bugs'. It was learned that, because of the Model's complexity, errors had been detected at various phases of its assessment. As a result, in some cases tapes of the Model had been distributed with incomplete corrections.

This technical note is a compilation of errors and corrections made to the AREAL Module at various times during its testing and installation in Canada. Several were concurred with by TARADCOM; others were brought to light during a meeting with Dr. P. Jurkat, one of the principal authors of AMC 74. Still more were discovered following the second meeting of the WG in Brussels, May 1978. Most of the errors were the result of programming oversight. Some were anomalies in the formation of equations, which required careful examination of the program.

HIGHLIGHTS OF CORRECTIONS

This section describes the highlights of the corrections and changes made in the program, as listed in the next section. Many of the coding errors were obvious from the programming point of view as they gave rise to error messages and caused abortion of the program during testing. Others were non-programming errors but mistakes attributed to the formulation of equations. Such errors were not easily detected but the need for their corrections could only be appreciated when one studied the details of the program.

The missing of variable names in the argument lists was detected in six places (items 1, 2, 3, 5, 9 and 10). These variables were not passed from the CALL statement to the SUBROUTINE statement but were used in the computation. While many computer systems would not accept undefined variables in the computational routines, others would take on arbitrary values in the system, leading to erroneous results.

In two DO-loops of the program (Items 6 and 7) the range was set to vary from 2 to a variable NAMBLY which means the number of running gear assemblies in the vehicle. This may not be allowed in other computers in the case when NAMBLY is unity. A test code was inserted to allow for this provision.

Miscoding is probably due to oversight in programming. Typographical mistakes (Items 4, 8 and 12) and mix-up of variable names (Items 12-18) have contributed to this kind of error which might lead to incorrect calculations.

The program erred in several logics which were used to determine the average patch speed (Items 20-23). In that particular routine some codes were found to be at variance with those documented in the AMC 74 report. These errors have given rise to strange results in some terrain units where the up-slope speed was predicted to be higher than the level speed for the same terrain conditions. Corrections were made to agree with the AMC 74.

Item 11 illustrates a case where a variable was not initialized but used in the program - another oversight in programming. To correct this, code was inserted to pre-define the variable. Alternatively it could be read in from the vehicle data file as it is one of the input parameters.

In several instances the program provided no protection against the occurrence of infinity due to division by zero. Correction was made by testing the denominator before the division was performed.

Item 19 shows a wrong sign used in the visibility equation. This error was not easily detectable until that routine was examined in detail. In formulating the solution of an equation for determining the vehicle speed limited by the driver's visibility, one of the terms assumed a wrong sign. The consequence was that the vehicle speed was estimated at higher values in some terrain units. The significance of the discrepancy was reflected when a vehicle was exercised on the Thailand terrain which is dominated by dense vegetation. It was found that the differences in speed values derived from the program after the correction accounted for almost 70 percent of the total terrain units in Thailand.

Another mistake in formulation of equation is observed in Items 26 and 27, where an energy term was incorrectly combined with a force term. In determining if a vehicle could override a single tree at a certain speed, the program added the force available from the vehicle to its kinetic energy to compare with the total resistance encountered. As can be seen the addition of terms was dimensionally inconsistent. After this error was communicated to TARADCOM a suggestion was made to convert the energy term to force required to fell a tree by dividing the kinetic energy of the vehicle by the average distance, determined to be 5.8 feet based on experience and empirical consideration. A factor of 12 was added to change the unit from feet to inches to make it consistent with other terms.

This latter error was the last detected by the writer. Although the correction has been incorporated in the program time did not allow the writer to rerun the program in full exercise to determine the effect of the change. It should be noted, however, that depending on the values in the equation the change may or may not affect the final result of a terrain unit speed prediction.

CORRECTION ITEMS

The errors and corrections made to the program are itemized in this section and follow a sequential order. The locations where the errors occurred are referenced by line numbers which are the identification numbers

appearing at the end of the records in the original program. Each item is illustrated by explanation for the change and should present no difficulty to readers having a general knowledge of FORTRAN programming.

The AMC 74 program is too bulky to be appended in this technical note. However a listing of the revised program can be referred to in another report (2). For clarity all the revised and new codes are documented in the program but they carry no identification numbers so as to distinguish them from the original codes.

ITEM 1. Line 4210
Variable VSS was missing in the argument list of CALL statement.

Original Code:
+ ,VOOBS ,VRIDE) 4210.

Revised Code:
+ ,VOOBS ,VRIDE ,VSS)

ITEM 2. Line 4290
Variable VT was missing in the argument list of CALL statement.

Original Code:
+ ,WGHT ,VTIRE) 4290

Revised Code:
+ ,WGHT ,VTIRE ,VT)

ITEM 3. Line 4870
Variable VSS was missing in the argument list of SUBROUTINE statement.

Original Code:
+ ,VOOBS ,VRIDE) 4870

Revised Code:
+ ,VOOBS ,VRIDE ,VSS)

ITEM 4. Line 5430
Variable name miscoded.

Original Code:
GCWB = 0.0 5430

Revised Code:
GCWB = 0.0

- ITEM 5. Line 5590
Variable VT was missing in the argument list of SUBROUTINE statement.
- Original Code:
 + , WGHT , VTIRE) 5590
- Revised Code:
 + , WGHT , VTIRE , VT)
- ITEM 6. Line 5880
New code was inserted before Line 5880 to guard against the occurrence of inconsistent DO-loop range.
- Original Code:
 DO 330 1=2, NAMBLY 5880
- Revised Code:

 IF (NAMBLY.EQ.1) GO TO 340 5880
 DO 330 1=2, NAMBLY
- ITEM 7. Line 6070
New code was inserted before Line 6070 to guard against the occurrence of inconsistent DO-loop range.
- Original Code:
 DO 410 1=2, NAMBLY 6070
- Revised Code:

 IF (NAMBLY.EQ.1) GO TO 411
 DO 410 1=2, NAMBLY 6070
- ITEM 8. Line 9590
Wrong operator.
- Original Code:
 VCICG(I,J) = 10.0 *.STF 9590
- Revised Code:
 VCICG(I,J) = 10.0**STF

- ITEM 9. Line 16820
Variable OBW was missing in the argument list of CALL statement.

Original Code:

+ ,LUNI ,NI, ,OBH ,OBL ,OBS 16820

Revised Code:

+ ,LUNI ,NI ,OBH ,OBL ,OBS ,OBW

- ITEM 10. Line 22190
Variable OBW was missing in the argument list of SUBROUTINE statement.

Original Code:

+ ,LUNI ,NI ,OBH ,OBL ,OBS 22190

Revised Code:

+ ,LUNI ,NI ,OBH ,OBL ,OBS ,OBW

- ITEM 11. Line 24600
Variable WRFORD was not initialized in the program. The following code was inserted before Line 24600: (Alternatively, WRFORD can be initialized as an input variable in the vehicle file)

WRFORD - 0

- ITEM 12. Line 29380
Variable name miscoded.

Original Code:

+ (GCW-GCWP) 29380

Revised Code:

+ (GCW-GCWB)

- ITEM 13. Lines 29550-29560
Variable names miscoded

Original Code:

DIMENSION NXX(20) 29550
NFL - NXX(L) 29560

Revised Code:

DIMENSION NFL(20)
NFLC - NFL(1)

ITEM 14. Line 29780
 Variable name miscoded

 Original Code:
 + CALL TFORCF(CF,CPFC, DOWP, IST,NFL,NVEHC, 29780

 Revised Code:
 + CALL TFORCF(CF,CPFC,DOWP,GCWP, IST, NFLC, NVEHC,

ITEM 15. Line 29880
 Variable name miscoded.

 Original Code:
 CALL SLIP(CPFC,IST,LOCDIF,NFL,NVEHC,SLIPX,YX) 29880

 Revised Code:
 CALL SLIP(CPEC, IST,LOCDIF,NFLC,NVEHC,SLIPX,YX)

ITEM 16. Line 30100
 Variable name miscoded.

 Original Code:
 CALL SLIP(CPFC,IST,LOCDIF,NFL,NVEHC,SLIPD,YD) 30100

 Revised Code:
 CALL SLIP(CPFC,IST,LOCDIF,NFLC,NVEHC,SLIPD.YD)

ITEM 17. Line 30240
 Variable name miscoded.

 Original Code:
 CALL SLIP(CPFC. IST,LOCDIF,NFL,NVEHC,SLIPN,YN) 30240

 Revised Code:
 CALL SLIP(CPEC,IST,LOCDIF,NFLC,NVEHC,SLIPN,YN)

ITEM 18. Line 30390
 Variable name miscoded.

 Original Code:
 CALL SLIP(CPFC,IST,LOCDIF,NFL,NVEHC,SLIPM,YM) 30390

 Revised Code:
 CALL SLIP(CPFC,IST,LOCDIF,NFLC,NVEHC,SLIPM,YM)

ITEM 19. Line 33540-33550
Coding mistake resulted from error in mathematical formulation.

Original Code:

C - -ACC*REACT	33540
VELV(K) = -(C- SQRT	33550

Revised Code:

VELV(K) = -ACC*REACT + SQRT(D)

ITEM 20. Line 36740
Variable VOVER(K,I) was not initialized in the program. The following code was inserted after Line 36470:

VOVER(D,I) = 0

ITEM 21. Line 36890
Programming error.

Original Code:

IF(XA.LE.OBSE-(WA+TL).AND.NV2FLG.EQ.0) GO TO 1902 36890

Revised Code:

IF(XA.LE.OBSE-WA+TL).AND.NV2FLG.EQ.0) GO TO 1903

ITEM 22. Line 36910
Programming error.

Original Code:

IF(FORMX(K).LT.ZZZ19A GO TO 1902 36910

Revised Code:

IF(FORMX(K).LT.ZZZ19A) GO TO 1910

ITEM 23. Lines 36940-36950
The following code deleted to cope with other changes in the same routine:

1902	VOVER(K,I) = 0	36940
	GO TO 1910	36950

ITEM 24. Line 37120
To avoid the division by zero the following code was inserted before Line 37120.
IF(VA(K,I)*VXT(K,I)*VBO(K,I).EQ.0.) GO TO 1910

- ITEM 25. Line 37400
To avoid the division by zero the following code was inserted
before Line 37400.
IF(VA(K,I)*VXT(K,I)*VBO(K,I).EQ.0.) GO TO 1910
- ITEM 26. Line 37740
Mathematical error in the equation.

Original Code:
IF(F+.5*GCW*VOVER(K,I)**2/385.9GT.STR(K,I)) GO TO 2001 37740

Revised Code:
IF(F+.5*GCW*VOVER(K,I)**2/385.95.8.12..GT.STR(K,I)) GO TO 2001
- ITEM 27. Line 37800
Mathematical error in the equation.

Original Code:
IF(F+.%*GCW*VAVOID(K,I)**2/#*%.(.GT.STR(K,I)) GO TO 2003 37800

Revised Code:
IF(+.%*GCW.VAVOID(K,I)**2/385.9/5.8/12..GT.STR(K,I)) GO TO 2003
- ITEM 28. Line 38280
To avoid the division by zero the following code was inserted
before Line 38280:

IF(VSLOPE(MUP)*VSLOPE(MLEVEL)*VSLOPE(MDOWN).EQ.0) GO TO 2108

or alternatively, the following code may be used for insertion:

IF(VSLOPE(MUP).EQ.0.0 GO TO 2108
IF (VSLOPE(MLEVEL).EQ.0.) GO TO 2108
IF(VSLOPE(MDOWN).EQ.0.) GO TO 2108

OTHER COMMENTS

Apart from the corrections discussed in previous sections, comment should be made on one of the subroutines in the program, which selects the vehicle speed over obstacles limited by driver tolerance to impact.

In SUBROUTINE IV17 (refer to lines 35000-35400 in the program). the maximum speed at which the vehicle will impact a single obstacle or a series of closely spaced obstacles was determined based on the consideration of vertical acceleration limited at the driver's station or on the cargo, to pre-determined maximum values. The speed was obtained by interpolation in tables produced by the Ride Dynamics Module, a sub-model executed independently of the Mobility Model.

Two tables of speed are provided. One is the speed versus obstacle height for impacts of the vehicle with discrete obstacles. The other is the speed versus obstacle spacing for the situation where the obstacle caused motion is not completely dampened before the next obstacle is encountered. The second table of speed is used for obstacles spaced closer than two vehicle lengths apart.

From the above consideration it is obvious that the speeds of a vehicle going over discrete obstacles would be different from those over closely spaced obstacles. But the formulation in the routine was quite intuitive in that it checked only the space between obstacles to decide which table of speed to use. If the space is farther than two vehicle lengths the first speed table is used for interpolation. If, on the other hand, the space is equal or closer than two vehicle lengths, the second speed table is used instead. The routine failed, however, to examine the effect of the first obstacle encountered in the event that even though the obstacles are closely spaced the height of the first obstacle may influence the vehicle speed limited by the vertical acceleration criterion. This lack of consideration was admitted by TARADCOM, but at the time of this writing no solution has been suggested. It is the writer's opinion that some thinking is required to arrive at a better strategy for selecting the vehicle speed over obstacles.

COMMENTS

The AMC 74 Mobility Model has been accepted by NATO AC225/P11 as an Initial NATO Reference Mobility Model. It is an attempt towards the standardization of an analytical technique, to be used by NATO countries, for the evaluation of vehicle performance. It represents the current state-of-the-art of vehicle mobility technology concerning the interactions of a vehicle, a terrain, and an operator. Much of the work was based on empirical and analytical relations with respect to vehicle-terrain-driver systems, which were derived from the laboratory and the field over many years of research and development.

When one considers that the model has been under frequent revision and that changes were made from time to time, it might not be surprising to see errors within the program. In its present form, the Model is still considered incomplete in some aspects, lacks reliability in others, and has not yet been fully validated in some parts or as a whole. Understandably it would require further improvements in accordance with the advances in vehicle technology and methods of terrain analysis. Hence, one would expect that a more efficient, and perhaps more complicated, Mobility Model would evolve through subsequent research and validation, and changes would undoubtedly take place in the Model and its sub-models. This technical note, therefore, serves a record keeping purpose for future reference and development.

REFERENCES

1. 'The AMC 74 Mobility', M.P. Jurkat, C.J. Nuttall, P.W. Haley, TR11921 (LL-149). U.S. Army Tank Automotive Command, Warren, Michigan, May 1975.
2. 'Conversion of the AMC 74 Mobility Program to DREO's SIGMA 9', J.E. Neilson. W.K. Ng. DREO Technical Note No. 79-21 (1979).

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATING ACTIVITY Defence Research Establishment Ottawa Department of National Defence Ottawa, Ontario, Canada K1A 0Z4		2a. DOCUMENT SECURITY CLASSIFICATION UNCLASSIFIED	
3. DOCUMENT TITLE CORRECTIONS MADE TO 'AREAL' MODULE OF THE AMC 74 MOBILITY MODEL		2b. GROUP N/A	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) TECHNICAL NOTE			
5. AUTHOR(S) (Last name, first name, middle initial) NG, Winson K.			
6. DOCUMENT DATE NOVEMBER 1979		7a. TOTAL NO. OF PAGES 12	7b. NO. OF REFS 2
8a. PROJECT OR GRANT NO.		9a. ORIGINATOR'S DOCUMENT NUMBER(S) DREO TECHNICAL NOTE NO. 79-29	
8b. CONTRACT NO.		9b. OTHER DOCUMENT NO.(S) (Any other numbers that may be assigned this document)	
10. DISTRIBUTION STATEMENT LIMITED DISTRIBUTION			
11. SUPPLEMENTARY NOTES		12. SPONSORING ACTIVITY	
13. ABSTRACT This technical note documents the corrections and changes made to the AMC 74 Mobility Model as of July 1978. The changes reflect the programming and mathematical errors discovered in the program as a result of in-house study and testing of the model. The corrections were made with the concurrence of the U.S. Army TARADCOM, the organization responsible for the development of the model. UNCLASSIFIED			

UNCLASSIFIED

Security Classification

KEY WORDS

AMC 74

AREAL

CORRECTION

MOBILITY

MODEL

MODULE

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the organization issuing the document.
- 2a. DOCUMENT SECURITY CLASSIFICATION: Enter the overall security classification of the document including special warning terms whenever applicable.
- 2b. GROUP: Enter security reclassification group number. The three groups are defined in Appendix 'M' of the DRB Security Regulations.
3. DOCUMENT TITLE: Enter the complete document title in all capital letters. Titles in all cases should be unclassified. If a sufficiently descriptive title cannot be selected without classification, show title classification with the usual one-capital-letter abbreviation in parentheses immediately following the title.
4. DESCRIPTIVE NOTES: Enter the category of document, e.g. technical report, technical note or technical letter. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.
5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the document. Enter last name, first name, middle initial. If military, show rank. The name of the principal author is an absolute minimum requirement.
6. DOCUMENT DATE: Enter the date (month, year) of Establishment approval for publication of the document.
- 7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.
- 7b. NUMBER OF REFERENCES: Enter the total number of references cited in the document.
- 8a. PROJECT OR GRANT NUMBER: If appropriate, enter the applicable research and development project or grant number under which the document was written.
- 8b. CONTRACT NUMBER: If appropriate, enter the applicable number under which the document was written.
- 9a. ORIGINATOR'S DOCUMENT NUMBER(S): Enter the official document number by which the document will be identified and controlled by the originating activity. This number must be unique to this document.
- 9b. OTHER DOCUMENT NUMBER(S): If the document has been assigned any other document numbers (either by the originator or by the sponsor), also enter this number(s).
10. DISTRIBUTION STATEMENT: Enter any limitations on further dissemination of the document, other than those imposed by security classification, using standard statements such as:
 - (1) "Qualified requesters may obtain copies of this document from their defence documentation center."
 - (2) "Announcement and dissemination of this document is not authorized without prior approval from originating activity."
11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.
12. SPONSORING ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring the research and development. Include address.
13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document, even though it may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall end with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (TS), (SI), (C), (R), or (U).

The length of the abstract should be limited to 20 single-spaced standard typewritten lines; 7 1/4 inches long.
14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a document and could be helpful in cataloging the document. Key words should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context.